April 11, 1950 M. M. SMITH 2,503,456

HEAT PUMP

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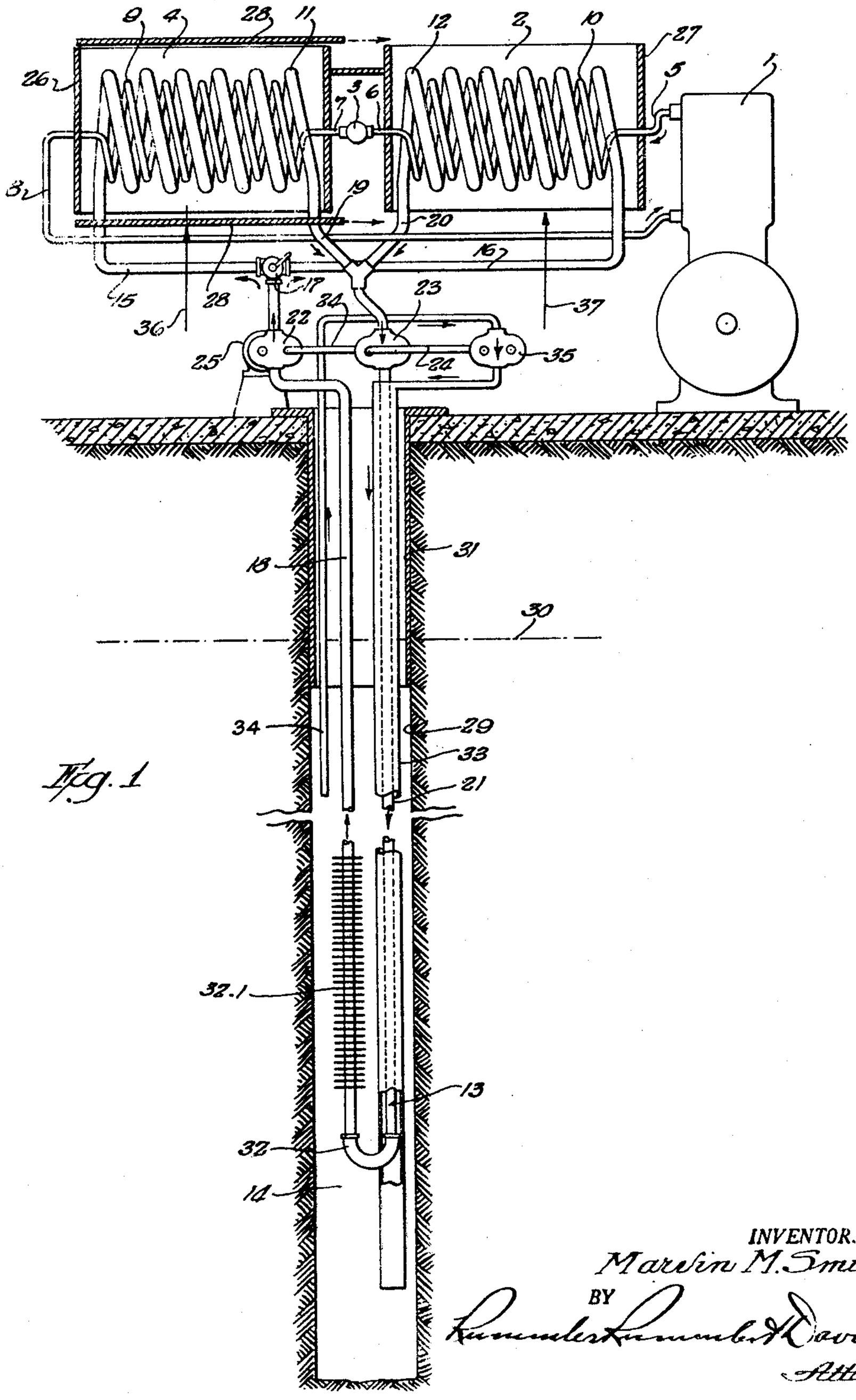

Fig. 1

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Fig. 2

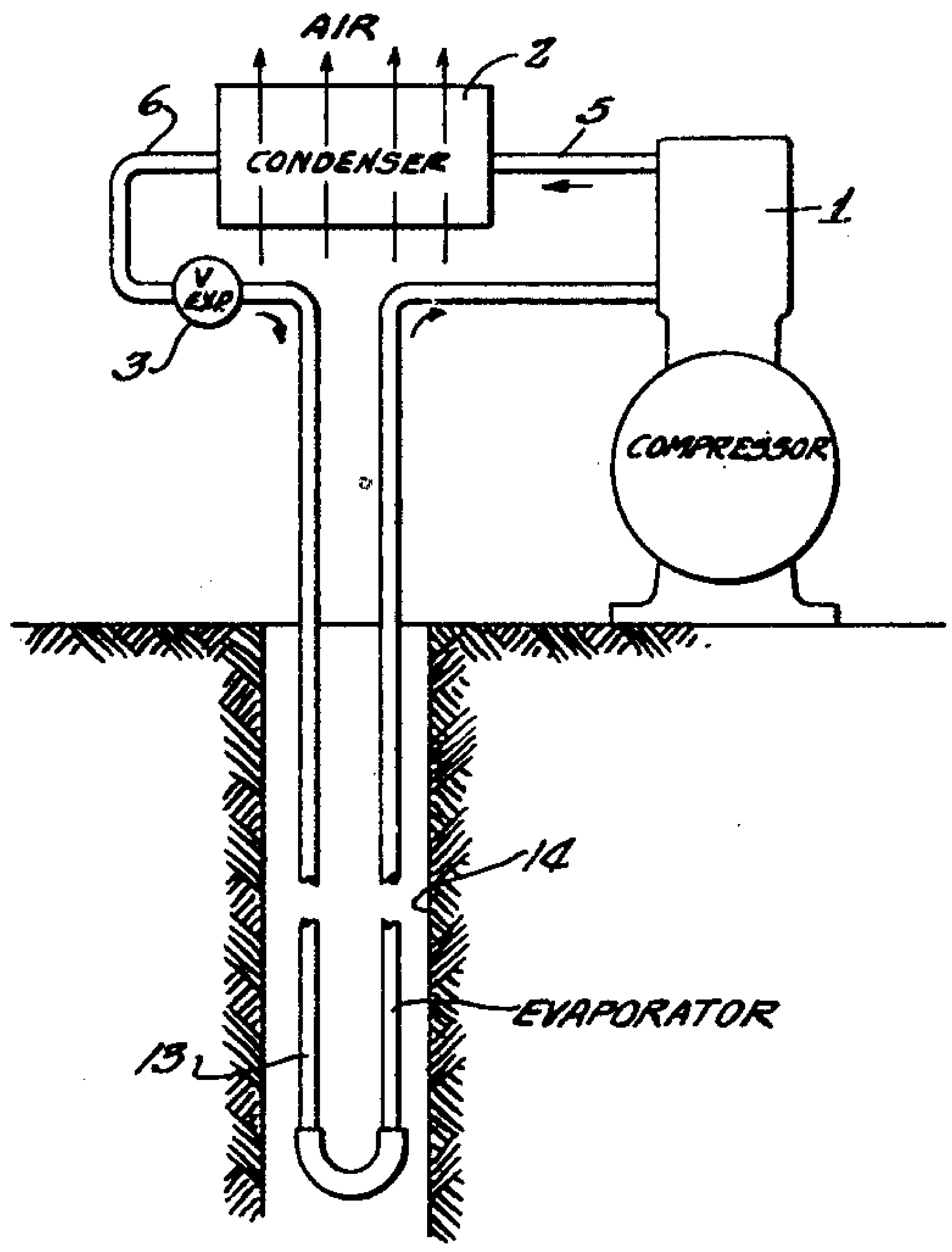
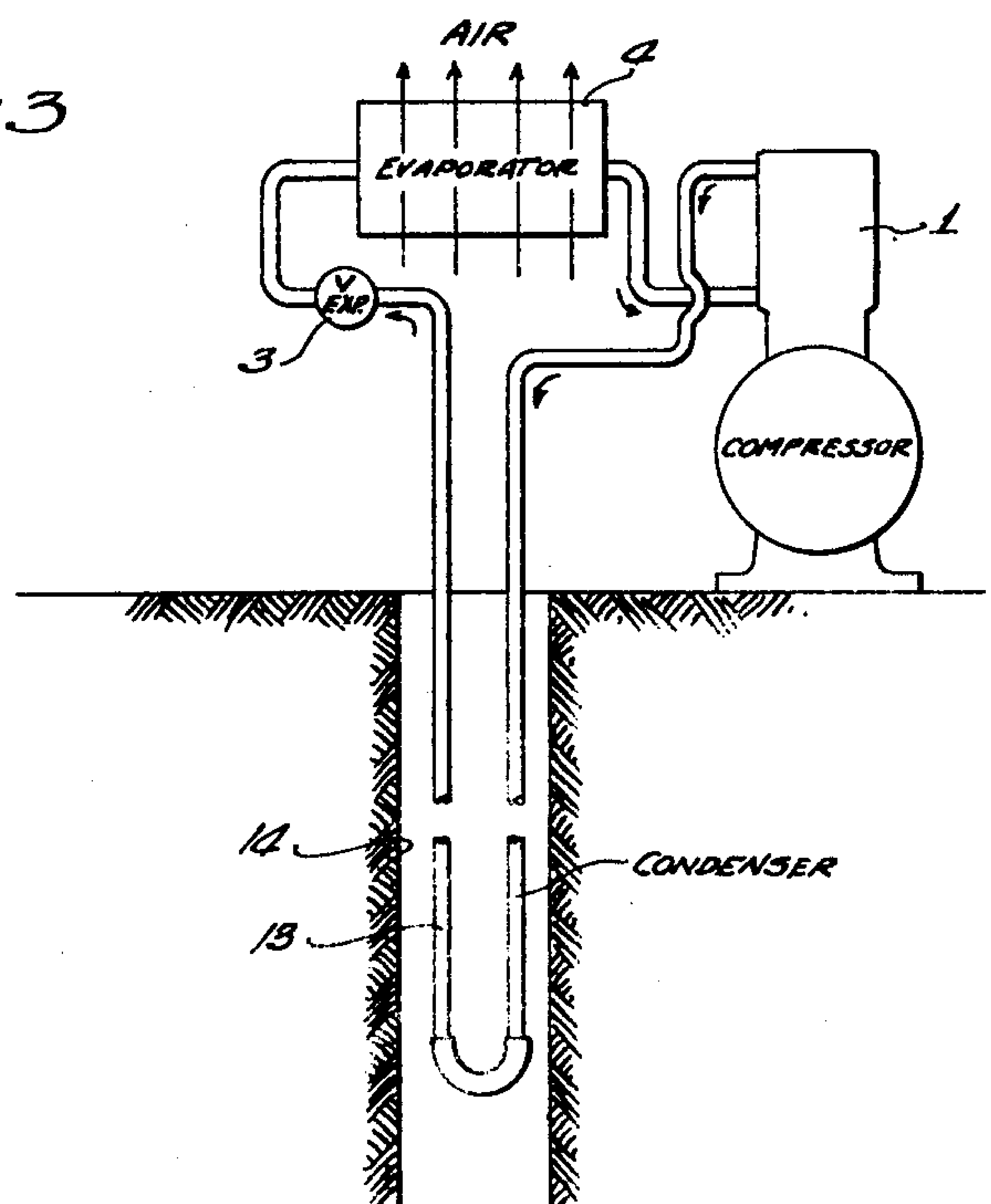


Fig. 3



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2,503,456

HEAT PUMP

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4 Claims. (Cl. 62—115)

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This invention relates to devices making use of the refrigeration cycle for pumping heat from one place to another and has particular reference to apparatus in which subterranean water is used as a source of heat which, combined with the heat of the mechanical energy expended in the operation of the apparatus, is utilized for the purpose of heating buildings. A suitable apparatus for this purpose is described in considerable detail in my copending joint application with Clesent O. Fields and Emory N. Kemler, Serial No. 574,478 filed January 25, 1945, which issued as Patent No. 2,401,890, July 11, 1946, and the present invention is mainly directed to improvements having particular reference to specific construction for utilizing the natural heat of a subterranean source in connection with apparatus of the general class of heat pumps represented by said patent.

The main objects of this invention are to provide an improved form of deep well apparatus for use in connection with devices operating in the refrigeration cycle; to provide improved means for utilizing the deep well either directly or indirectly as one of the heat transfer elements of the refrigeration cycle; and to provide improved means for insuring effective transfer of heat to or from the water of the deep well in environments where the water of the well may be normally static.

A specific embodiment of this invention is shown in the accompanying drawings in which:

Figure 1 illustrates diagrammatically a heat pump apparatus having deep well connections arranged in accordance with this invention. Some apparatus features not essential to the operation of this invention are omitted to simplify the disclosure.

Fig. 2 is a diagrammatic view of a modified arrangement in which the deep well is used directly as the evaporator of the refrigeration cycle.

Fig. 3 is a diagram of a modified form of the same in which the deep well serves directly as the condenser element of the refrigeration cycle.

In the form shown in Figure 1, the principal elements of the refrigeration cycle of the heat pump are represented by a compressor 1, a condenser 2, an expansion valve 3, and an evaporator 4 connected in a closed circuit for circulation of a refrigerant by means of pipes 5, 6, 7 and 8.

The heat-exchange devices which serve as condenser and evaporator in this refrigeration cycle comprise refrigerant coils 10 and 9 respectively, and a second set of coils 11 and 12 whereby a liquid heat-conveying medium is circulated in heat-transferring relation to the coils 9 and 10. The coils 11 and 12 are separately connected, in closed circuit to an elongated U-tube 13 extending into a deep well 14.

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The inlet ends of the coils 11 and 12 are connected by pipes 15 and 16 respectively through a three-way valve 17 to one leg 18 of the U-tube 13 and their outlet ends are connected by pipes 19 and 20 respectively to the other leg 21 of the U-tube 13. The legs of the U-tube are equipped with circulating pumps 22 and 23 respectively which may have a common drive shaft 24 driven by a motor 25 or belted to the motor of the compressor as will be understood.

The circulating pumps 22 and 23 work in opposite directions for continuous circulation of the liquid contents of the U-tube and its connected piping. The medium contained in this piping may be any suitable liquid that is anti-freezing in the range of temperatures that might exist at any time at any point along its length.

The heat-transferring coils of the evaporator and condenser are separately enclosed in tubular housings 26 and 27 which may be alternately closed by a pair of baffles 28 which are shiftable so as to cause the air that is to be conditioned by the apparatus to flow either through the evaporator housing 26 when the air is to be cooled by the apparatus or through the condenser housing 27 when the air is to be heated.

Similarly, the three-way valve 17 may be shifted so as to supply circulating medium either to the coil 11 of the evaporator or to the coil 12 of the condenser so as to be effective only in that respective heat-transfer device which is cut off from the air flow.

The deep well apparatus of the present invention consists of a bore 14 extending down into the earth to a sufficient depth to insure that it reaches well below the normal level of the subterranean water represented by the broken line 30. The bore 14 is provided with a suitable casing 31 in its upper part. The bore may be comparatively small in diameter and may extend deep into the earth. It will, of course, be understood that dimensions of the well and piping are subject to variations according to the capacity of the apparatus.

A suitable form of U-tube for use in such a well might consist of a pair of pipes 18 and 21, assembled in parallel relation to each other, as shown in the drawings, and connected at their lower ends by means of a U-fitting 32. Fins 32.1 may be provided for increasing the heat transferring surface of the tube 13.

In the illustrative modifications shown in Figs. 2 and 3, the deep well U-tube is employed directly as a part of the piping circuit through which the refrigerant is circulated. In Fig. 2 the U-tube serves as the evaporator and in Fig. 3 it serves as the condenser of the refrigeration cycle. In each of these cases, the compressor 1 serves as a circulating pump and it is unnecessary to equip the U-tube with the circulating pump of Figure 1.

When the heat pump is used for cooling air, the air is directed over the coils of the evaporator as indicated by the arrow 36, in Fig. 1; and when the heat pump is used for heating air, the flow of air is directed over the coils of the condenser as indicated by the arrow 37 in Fig. 1. It is thought to be unnecessary, in view of the present state of the art, to include in this disclosure the surrounding casing and arrangement of air ducts, blower and other devices for controlling such air flow. A suitable structure for this purpose is shown in the before-mentioned copending application, Patent No. 2,401,890.

It is important that there be no substantial transfer of heat from one of the legs of the U-tube to the other in the upper part of the U-tube and that the water in the well be kept in motion, especially if the well is of comparatively small diameter. To this end the down-flow leg 21 of the U-tube 13 in Fig. 1 is enclosed in a tubular casing 33 which extends from the top of the well throughout the length of the leg 21, being spaced from the walls thereof to form a duct, which is preferably extended below the bottom of the U-tube if the depth of the well permits. A water-intake pipe 34 extends into the upper part of the well from a point substantially below the normal water level 30 to the top of the well where it is joined to the casing 33 through a water pump 35, whereby water is taken from the upper part of the well and is forced to flow along the leg 21 of the U-tube and to the lower part of the well. The water of the well thus has a heat-transfer stimulating action by reason of its wiping effect along the surfaces of the U-tube and also over the walls of the well. This last-named circulating pump 35 may also be driven by the same motor 25 that operates the pumps 22 and 23.

In the operation of the system shown in Fig. 1, with the system functioning for heating purposes, the air to be heated is directed across the condenser portion 2, as indicated by the arrow 37, the baffle 28 being in position to block off the evaporator portion 4. The three-way valve 17 is set to direct the heat transfer fluid, in the closed circulating system of the U-tube 13, through the heat exchanger coil 11 and then back to the U tube and the pumps 22 and 23 are operated to force the fluid circulation.

With this adjustment heat from the well water is conveyed, by the closed liquid circulating system, directly to the evaporator coils 9 of the heat pump system and absorbed by the refrigerant in the heat pump system. Such heat is then delivered through the compressor 1 to the condenser coil 10 where it is transferred by convection to the air passing through the condenser portion 2.

The circulation in the closed heat transferring fluid system is upward from the well through the U-tube leg 18, through the pump 22 and downward into the well through the U-tube leg 21 by way of the pump 23. Thus the cooled fluid from the coil 11 is returned to the well where it is reheated by absorption from the well water surrounding the U-tube.

In order to prevent cooling of the well water in the upper portion of the well, where the highest relative well water temperature is desired, the downward leg 21 is insulated throughout its length by means of the jacket tube 33. Also the well water is circulated through the jacket tube in order to immediately begin the process of reheating the circulating heat conducting fluid. Such well water is taken from the upper portion of the well and is discharged adjacent the bottom of the well in order to provide a maximum of heat exchange contact with the well sides as the well water is thus progressively moved or circulated within the well bore.

When the heat pump system is operated for cooling purposes, the baffle 28 is shifted to close off the condenser portion 2 and the air to be cooled is directed through the evaporator portion 4. Under these conditions the valve 17 is turned to direct the flow of heat conducting fluid from the pump 22 to the coil 12 and the heat conducting fluid then serves the function of removing heat from the heat pump system and dumping such heat into the well where it is dissipated to the ground.

Under these circumstances the well serves as a cooling means. However, the flow of fluid through the U-tube portion of the closed circulating system is the same as when operating on the heating cycle. In this case the jacket tube 33 serves to prevent heating of the well water at the upper portion of the well and the well water circulating through the jacket removes most of the heat from the heat conducting fluid in the leg 21 and dumps the heated water at the bottom of the well bore whereby maximum heat transfer contact between the walls of the well and the water moving in the well is obtained.

Although one specific embodiment of this invention is shown in considerable detail and some modifications are also herein shown and described, it will be understood that numerous details of these constructions may be altered or omitted without departing from the spirit of this invention as defined by the following claims.

I claim:

1. In a heat pump, a refrigeration cycle apparatus comprising a compressor and a pair of refrigerant heat exchange members connected to function as condenser and evaporator respecitvely, a well bore extending into the earth, and a closed circuit heat-conveying fluid circulation conduit comprising means arranged in heat transfer relation to one of said refrigerant heat exchange members and including a U-tube extending into said well bore in series with said conduit, said U-tube having heat transfer relation to the contents of the well bore.

2. In a heat pump system, a refrigerant circulating system, a well bore extending below the prevailing subterranean water level and in communication with such water, a U-tube extending into said well bore to a point below said water level, a closed circulatory piping system including a portion having heat exchange relation to said refrigerant circulating system and including said U-tube and a pump, a heat conducting liquid in said U-tube and circulatory piping system, a casing enclosing one leg only of said U-tube, and means including a second pump for causing the water in said well to circulate through said casing.

3. In a heat pump system, a well bore extending below the prevailing subterranean water level, a U-tube extending into said well bore to a point below said water level, a closed circulatory piping system arranged in heat exchange relation with the heat pump and including a pump in said system above said U-tube, a heat conducting liquid in said U-tube and circulatory piping system, and mechanical means for causing the water in said well to circulate about said U-tube, said mechanical means comprising a casing enclosing and forming a water passage extending along one leg only of said U-tube, and means including

a pump for forcing a flow of water from said well and through said casing parallel with the flow of liquid in said one leg.

4. In a heat pump system, a well bore extending below the prevailing subterranean water level, a U-tube extending into said well bore to a point below said water level in heat transfer relation thereto, a closed circulatory piping system arranged in heat exchange relation with the heat pump and including a pump in said system above said U-tube, a heat conducting liquid in said U-tube and circulatory piping system, mechanical means for causing the water in said well to circulate about said U-tube, said mechanical means comprising a casing enclosing and forming a water passage extending along one leg only of said U-tube from the upper part of said well to a point substantially below the bottom of said

U-tube, and a pump for forcing a flow of water from said well and through said casing.

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